treatment of the three-body problem. Esclagnon and Bohl have indicated applications of quasi-periodic functions to the ordinary problem; special cases in which the masses vary with the time have been considered by Mestchersky; Laves has studied the integrals when the forces depend upon the coordinates and their derivatives of the first two orders; and Ebert has taken up the problem in space of any number of dimensions.

Bertrand inverted the problem of two bodies by proposing to find the law of force under which a body, whatever may be its initial position and velocity, always describes a conic section. This inverse problem was solved independently by Bertrand, Darboux and Halphén; and extended by Dainelli to general curve trajectories. Stephanos has recently given another generalization of Bertrand's problem by including in the discussion the case in which the force has not necessarily an unique direction at every point of the conic section. This problem in turn has been generalized to conditions which include the conic section trajectories as special cases. Griffin observed that the law of force under which a given curve is described as a central orbit can not be determined uniquely if only the position of the center of force be known. Oppenheim gave to Bertrand's problem a new treatment which included the case of finding the central conservative forces under which three bodies of arbitrary mass describe given plane curves.

A further generalization of Bertrand's problem presents itself in the problem of finding the forces of a central conservative system capable of maintaining a system of m particles on as many prescribed but arbitrary orbits in a space of n dimensions. The resolution of this problem shows that the central conservative character of the motion and the equations of the orbits are necessary and sufficient to determine the components of the velocities, only in the case of $\frac{1}{2}n(n+1)$ bodies, and the components of the forces only in that of $2n-1$ bodies. From this point of view the plane three-body problem possesses an unique generality of its own, in that it is the only case in which all the elements of the mechanics of the problem are completely determinate when the arbitrary plane curves described by the bodies under central conservative forces are given. This circumstance has been turned to account in the construction of new integrable problems of three bodies under laws of force involving only the masses and the mutual distances of the bodies.

EDGAR ODELL LOVETT
THE RICE INSTITUTE,
HOUSTON, TEXAS

THE PHYLETIC IDEA IN TAXONOMY[1]

TO-DAY every botanist is an evolutionist. It may well be that we have not yet agreed as to the details—as to the particular manner in which modifications were effected—whether they were by slow and almost imperceptible deviations from the parental type, or those more marked variations that we are in the habit to-day of calling "mutants." Some of us may lay more stress upon the "survival of the fittest," others upon the "survival of the unlike." For some the "struggle for existence" may account for the diversity of plant forms, while others see in "adaptation" the explanation of the same diversity. To some the "inherent tendency" in plants to vary is a potent factor, while for others all variation is a result of "environment." Yet with all this diversity of opinion as to details there is a practical unanimity as to the acceptance of the general doctrine of evolution. It may be asserted without fear

[1] Address of the vice-president and chairman of Section G—Botany—of the American Association for the Advancement of Science, Baltimore, 1908.

of contradiction that all scientific botanists hold that the vegetable kingdom as we know it to-day is the result of a series of evolutions from lower to higher types of plants, and that every higher plant owes its present structure to the favorable modification of some ancestral lower plant. To-day when we study the particular structure of any plant we consider it to be the result of the modifications that have taken place in its phylogenetic history. No botanist now considers a species to be a separate or special creation, but rather a more or less distinguishable variation from some other form.

With such an agreement among botanists as to the validity of the doctrine of evolution, it needs no argument to sustain the thesis that a natural classification must be an expression of a theory of evolution. Such taxonomic terms as "higher," "lower," "primitive," "derived," "relationship," "affinity," etc., can have no other significance than that given them by the doctrine of evolution. To-day there are no hidden or occult meanings to be attached to plant structures. We no longer credit the doctrine of signatures, whether in medical or systematic botany. We no longer seek to find the characters which in some mysterious way are the special marks of classes, nor those which are necessarily ordinal marks, or the characteristic marks of families, and so on to genera and species. And yet it is not so very long since a great biologist seriously set about trying to do this very thing. You will remember that Agassiz made this attempt[2] about fifty years ago, and that he actually formulated his plan in definite terms. I may as well quote the paragraphs in which he states his method of characterizing different groups. They are as follows:

Branches or *types* are characterized by the plan of their structures;

Classes, by the manner in which that plan is executed, as far as ways and means are concerned;

Orders, by the degrees of complication of that structure;

Families, by their form, as far as determined by structure;

Genera, by the details of the execution in special parts; and

Species, by the relations of individuals to one another and to the world in which they live, as well as by the proportions of their parts, their ornamentation, etc.

With regard to these he says a little later[3] that "the branches, the classes, the orders, the families, the genera, the species, are groups established in nature respectively upon different categories," and declares that he feels "prepared to trace the natural limits of these groups by the characteristic features upon which they are founded," that is, upon those which have just been enumerated in my quotation.

In the common systematic characters as drawn up by many botanists in the recent past there has been something of the old-time notion that we are dealing with fixed groups whose limits are indicated to us by certain rather definite structural characters which nature has accommodatingly attached to all plants in these groups. The thought seems to have been that plants are "tagged" or "branded" with the peculiar marks of the group, these marks having otherwise no particular significance. One is reminded of the similar use which stockmen on the plains make of arbitrary names, monograms or hieroglyphics for indicating what animals belong to this or that particular ranch. And it appears that this view of the meaning of taxonomy and the significance of characters has not wholly died out. The most reasonable explanation of the inordinate species making practised by some botanists is that they are still under

[2] "An Essay on Classification," by Louis Agassiz, London. The preface dated December, 1858, p 261.

[3] "An Essay on Classification," p. 263.

the dominance of the old doctrine of the fixity and inviolability of characters, especially the characters of species. When one holds this view it is very easy for him to find in every variation the indication of a new species, for all one must do is to find that every varietal character is really specific according to such rules as those laid down above by Agassiz. One may logically hold that if characters of a particular kind are of "specific" value, they must be valid, however faint or obscure they may be. Probably the recently observed activity in the making of new species is the flickering of the dying flame of this expiring theory. Wholly inconsistent with the doctrine of evolution, it must soon die out, and we may well be patient while it lasts, praying in the meantime that its final happy extinction may not be long delayed.

I need scarcely refer here to the "map theory" of relationship which was once quite the vogue, and of which remnants are still to be seen in some charts showing the relationships of groups. In some of these we still see an attempt to indicate the genetic relationship of a particular group in more than two directions! Before the general acceptance of the doctrine of evolution such an indication of relationship was quite consistent, for into taxonomy no definite conception of genetic relationship had yet entered. Groups of plants were thought of as related to one another, as we think of the relationship of one state to another on a map. And no doubt it was a helpful device for giving clearer notions of the similarities between plant groups. Just as the children in the schools learned much by the exercise of "bounding" the states, so it was profitable in those ante-evolutionary days to use these imaginary maps to show similarities by nearness or juxtaposition. Yet while the practise may once have been profitable, it is no longer so, and to engraft genetic ideas upon it is really quite impossible.

There is still another conception of plant taxonomy to which I must advert, namely, the philosophical division of the vegetable kingdom into convenient groups of various grades, as divisions, subdivisions, classes, subclasses, orders, suborders, etc. Such groups are in a sense natural, in that they are usually characterized by structures which are conceived to have been evolved from others somewhat like them. Yet these have failed to commend themselves permanently, no doubt because generally they have been based upon only one or at best a few closely related characters. Thus the somewhat recent attempt to divide the vegetable kingdom into Protophytes and Metaphytes is an apt illustration, as is also its earlier division into Phanerogams and Cryptogams. And of like nature was the suggestion to divide the dicotyledonous plants into Chalazogamae and Porogamae. The proposal made by Sachs to divide the Thallophytes into Zygosporeae, Oosporeae and Carposporeae, while no doubt it did much to dispel the confusion with regard to the plants included, failed to commend itself generally because it separated clearly related groups of plants. The failure of this arrangement was due not so much to the fact that it was based upon one character—namely, the mode of sexual reproduction—as to the far more important fact that it took practically no account of the evolution of the plants constituting the groups. Herein was its weakness, and in spite of the advantage of clearness and ease of understanding which it possessed to a marked degree, it was never adopted by systematic botanists.

A few columns back I said that a natural classification must be an expression of a theory of evolution. I will go farther now and say that it is sound scientific practise to change our classification when we change our theory of evolution. This follows logically as a corollary of the main thesis, but it is well to place our acceptance of it on record, lest in our zeal for consistency we may neglect it. No system of classification should stand in its entirety after the theory of evolution upon which it is based has experienced any change whatever. The two must be modified simultaneously, for they are parts of a common system.

What does the theory of evolution involve to-day? It will be well to pause here for a short enumeration of the principal features of this theory so far as they bear upon the question of classification. I need scarcely remind you that for the purposes of this discussion it is not necessary to decide between the different schools of evolutionists, since their differences are almost wholly of such nature as to have little or no bearing upon a system of plant taxonomy.

Elsewhere[4] I have enumerated the following dicta as involved in the theory of evolution as applied to the vegetable kingdom:

1. In general the lower plants came into existence first.
2. In general the higher plants sprang from the lower.
3. Higher plants are more complex than the lower.
4. Structures with many similar parts (homogeneous) are lower, those with fewer and dissimilar parts (heterogeneous) are higher.
5. Evolution is not always upward, but often involves degradation and degeneration.
6. Evolution does not necessarily involve all organs of the plant equally in any particular period.
7. One organ of a plant may be advancing while another is retrograding.
8. Upward development is sometimes through an increase in complexity, and sometimes by a simplification of an organ or a set of organs.
9. In some cases particular structures become more simple while the plants themselves become more complex.
10. Evolution has generally been consistent, and when a particular progression or retrogression has set in it is persisted in to the end of the phylum.
11. Retrogression, once set in, usually persists, and is not followed by a progression.
12. Hysterophytic degeneration is persistent, and the hysterophytic phylum never becomes holophytic.
13. In the first stages in the development of any organ, whether upward or downward, the new structures are not as fixed as they become later, and in these earlier conditions there may be reversions to the ancestral structures, while later such reversions do not occur.
14. All plant relationships are genetic.
15. Plants are related *up and down* the genetic lines, and the system of plants to be quite natural must recognize these phyla.

While these fifteen dicta are by no means all that might be cited, they will suffice for my present purpose. From them the phyletic idea in taxonomy follows logically. Since all natural groups must be phyletic, only that arrangement is natural that recognizes these in their entirety. It should no longer be permissible on scientific grounds to propose a classification which is not phyletic.

We may now profitably inquire as to the origin of phyla, and to seek an answer as far as it is possible to find one in general terms and on theoretic grounds. Stated philosophically, from what we know of the relationship of organic beings it is obvious that a phylum originates with the incoming of a new idea. Stated structurally, it has its beginning with the development of a dominant morphological peculiarity. Stated taxonomically, its initial point is indicated by the appearance of a new character.

Every phylum is the result of a development which differs from that which preceded it because of the incoming of a new dominant idea. This dominant idea was manifested structually by a divergence

[4] "A Synopsis of Plant Phyla," *University of Nebraska Studies*, October, 1907, p. 1.

from the previous lines of evolution, and this point of divergence is the actual origin of the new phylum. As far as this idea dominates, so far does the phylum extend, and when a still newer idea comes in and attains dominance, a still newer phylum has its beginning.

In this manner may we mark the beginning and the extent of phyla. They originate with a divergence which is the expression of a new idea. It is what we often call a "tendency." In taxonomy we refer to it as a "new character," this latter term being sometimes somewhat confusingly applied to the underlying idea and sometimes to its obvious structural expression.

The result of the successive development of phyla is quite like that in a tree where newer branches spring from older ones by the formation of buds, from which branches develop in succession. And as there are branches of all grades, from the primitive diverging growths which eventually divide the tree profoundly into great segments, through the smaller and smaller branches to the very recent slender twigs—the growths of but yesterday—so it is with the development of successive phyla from one another, the result being a complex tree-like aggregation with older phyla below and younger and smaller phyla above.

In order to discern phyla, the botanist must certainly be familiar with the whole vegetable kingdom, or at the least with the great region in which the particular phyla under consideration occur. He must be able to bring to mind the families, genera and species of plants with such clearness as will enable him to see the direction of the evolutionary current—the "drift" of evolution in the vegetable kingdom as a whole, and in the particular portion immediately under his consideration. I know that this is often a difficult task, just as it may be very difficult to determine the direction of the water current in a lake by observations at one point only: yet it may be very easy when the points of observation are multiplied. So it is here difficult, and perhaps impossible, for the man whose point of view is limited to a small portion of the botanical shore-line. The trained eye of the experienced man can catch the drift of the waters from a few properly selected points of observation, and likewise the trained eye of the botanist from observations at properly selected stations may detect the direction of evolutionary progress, as well as the origin and extent of the resulting phyla.

Applying what has been suggested in the foregoing brief and somewhat desultory discussion, it appears to me that we may recognize the following plant phyla of primary rank:

1. *Myxophyceae*, in which the dominant idea is the simple nucleus, typically not limited by a nuclear membrane. The simple plant body, of one or only a few cells, the blue-green diffused pigment, and the soft and often gelatinous walls may be regarded as characters of secondary importance.

Here are included also many hysterophytes (bacteria) which I regard as degenerates from the normal plants of this phylum.

Probably from the highest *Myxophyceae* came the second phylum—

2. *Protophyceae,* in which the dominant idea is the definite nucleus, limited by a nuclear membrane. The simple plant body of one cell or of a repetition of mostly similar cells, the typically motile, ciliated gametes, the definite chromatophores carrying a chlorophyll-green pigment, and the usually firm cell wall, are limiting secondary characters.

I here include *Pleurococcaceae, Ulvaceae, Ulotrichaceae, Oedogoniaceae, Coleochae-*

taceae, and a dozen or so related families. This phylum has been unusually productive of other phyla of primary and secondary rank, and elsewhere[5] I have hazarded the suggestion that from the lower *Protophyceae* (near *Protococcoideae*) a phyletic line passed off and gave rise to the animal kingdom.

Springing from the filamentous *Protophyceae* is the third phylum—

3. *Zygophyceae*, in which the sluggish cells easily separate, and the non-ciliated gametes move feebly. This is a phylum on the down-grade, and all of its members show structural degeneration. In the desmids and diatoms the filaments usually separate early into single cells, resulting in the so-called "unicellular" structure of these plants.

The filamentous pondscums (*Spirogyraceae*, *Zygnemataceae* and *Mesocarpaceae*) are here held to have given rise by early fragmentation to several secondary phyla, including the three families of desmids, and the many families of diatoms.

From the filamentous *Protophyceae* there came also the fourth phylum—

4. *Siphonophyceae*, in which the dominant idea is the development of coenocytes. The retention of the typically motile ciliated gametes producing simple zygotes upon uniting, the chlorophyll-green chromatophores, and the mostly filamentous or upright plant body which is rooted below, are important secondary characters.

Beginning with the segmented *Cladophoraceae* two secondary phyla may be recognized—one (*Vaucherioideae*) of filamentous plants—the other (*Bryopsidoideae*) of upright and branched plants. Many species have degenerated into hysterophytes.

Again, from the filamentous *Protophyceae* came the fifth phylum—

5. *Phaeophyceae*, in which the dominant feature is the addition of the brown pigment (phycophaein) to the chlorophyll of the cells. The typically motile, ciliated gametes, producing simple zygotes upon uniting, and the filamentous to massive plant body, rooted below, are secondary limiting characters.

Starting with the filamentous and often small *Ectocarpaceae*, this group readily divides itself into two well-marked secondary phyla—*Phaeosporeae*, and *Cyclosporeae*, the former culminating in the gigantic *Laminariaceae*, and the latter in the highly developed *Sargassaceae*.

Going back again to the fertile group of the filamentous *Protophyceae*, we find the origin of the sixth phylum—

6. *Carpophyceae*, whose dominant characters are the reddish pigment (phycoerythrin) added to the chlorophyll of the cells, and the growth of the zygote into a spore-fruit. The mostly erect, symmetrically branched and basally-rooted plant body, and the definite attainment of heterogamy, afford important secondary characters.

Here the typically marine *Bangioideae* and *Florideae* dominate the phylum, and these develop phycoerythrin in their cells, while the green fresh-water *Charoideae* constitute a small side line.

From the more primitive, probably filamentous *Carpophyceae* came the seventh phylum—

7. *Carpomyceteae*, whose dominant idea is the abandonment of the holophytic habit, and the adoption of the hysterophytic habit, with the disappearance of chlorophyll, resulting in the atrophy of the vegetative portions of the plant body and the increase in reproductive structures.

[5] "The Structure and Classification of the Lower Green Algæ," in *Trans. Am. Mic. Society*, Vol. XXVI., 1905, pp. 121–136; and later in "A Synopsis of Plant Phyla," 1907. See also my "Essentials of Botany," sixth edition, 1896, pp. 137–8.

The spore-fruit inherited from the preceding phylum undergoes many changes and is often degenerated, and this sometimes involves the gametes themselves.

This phylum is one of marked departure from the general upgrade evolution in the vegetable kingdom, and its successive smaller phyla show increasing degeneration in the structure of the plant body, which in the rusts and smuts becomes excessive, while in some cup-fungi (*Pezizales* and *Helvellales*), puff-balls (*Lycoperdales*) and toadstools (*Hymenomycetales*) the spore fruit is relatively very large.

From the higher *Protophyceae* (probably near Coleochaetales) came the eighth phylum—

8. *Bryophyta,* in which the dominant idea is the growth of the zygote into an alternate, short-lived generation, the sporophyte, and the consequent adoption of the land habit.

The two secondary phyla are *Hepaticae* and *Musci.*

From the lower *Bryophyta* (probably near *Anthocerotales*) came the ninth phylum—

9. *Pteridophyta,* whose dominant character is the growth of massive roots and broad leaves upon the sporophyte, rendering it long-lived and independent, and resulting in the postponement of spore formation.

It must be noted here that I use the term *Pteridophyta* in the narrower sense, limiting it to ferns (*Filicinae*) and excluding lycopods and horsetails. The incoming of heterospory in some ferns is a significant fact.

From the lower *Pteridophyta* (probably near *Ophioglossales*) came the tenth phylum—

10. *Lepidophyta,* in which the dominant character is the long-lived, erect cylindrical stem of the sporophyte, which bears massive roots below, is covered with many small scattered leaves, and terminates in a strobilus of imbricated sporophylls above.

From the lower *Pteridophyta* again (probably near *Ophioglossales*) came the eleventh phylum—

11. *Calamophyta,* in which the dominant character is the long-lived, erect, cylindrical stem of the sporophyte, which bears massive roots below, regularly whorled leaves and branches, and terminates in a strobilus of whorled sporophylls.

In the two preceding phyla, heterospory, although present, has not yet become fixed. In both the increased definiteness of the strobilus is significant.

From other lower *Pteridophyta* (near *Marattiales* of *Isoetales*) came the twelfth phylum—

12. *Cycadophyta,* in which the dominant idea is the uniform production of heterospores in simple strobili of open sporophylls, upon the megaphyllous, spongy-wooded sporophyte, and the permanent retention of the megaspore in the sporangium, thus forming the seed.

I here include not only the cycads proper (*Cycadineae*), but also the much more primitive "seed ferns" (*Cycadofilices*), the ancestral conifers (*Cordaitineae*), the ancestral flowering plants (*Bennettitineae*), and the maiden-hair trees (*Ginkgoineae*).

From *Cycadophyta* came the—

13. *Gnetales,* if indeed they are not to be regarded as belonging to that phylum.

The three genera are doubtless the surviving remnants of former rather well developed secondary phyla, now nearly extinct.[6]

From the *Cycadophyta* came the fourteenth phylum—

14. *Strobilophyta,* in which the dominant idea is the development of definite,

[6] Consult here Arber and Parkin's paper on the Gnetales, in *Annals of Botany,* Vol. XXI. (1908), p. 489.

compact strobili of open microsporophylls and megasporophylls upon the microphyllous, solid-woody sporophyte.

I regard the cone-bearers proper—*Taxodiaceae, Araucariaceae, Abietaceae, Cupressaceae,* etc., as more primitive, and that from these have sprung such specialized forms as *Podocarpaceae, Phyllocladaceae* and *Taxaceae*.

From the *Cycadophyta* came also the fifteenth phylum—

15. *Anthophyta,* in which the dominant idea is the closure of the megasporophyll, and the transformation of the plain strobilus into the ornamental flower.

I am very glad to be able to suggest the restoration of the wholly appropriate name —*Anthophyta*—for this phylum. As I conceive this immense group, it is rather sharply divided into three secondary phyla which diverge from a common point of beginning—the so-called "Ranalian plexus." Two of these secondary phyla are dicotyledonous, while the third is monocotyledonous. The first culminates in the mints (*Lamiales*), the second in the sunflowers (*Asterales*) and the third in the orchids (*Orchidales*).

With regard to the relationship of the four phyla last named many facts have been brought to light during the past few years, which have quite materially modified the generally prevailing theories. With the publication of Wieland's epoch-making book on American cycads[7] attention has been centered upon the primitive cycads as the group of gymnosperms from which the angiosperms must have sprung. It is no longer a tenable hypothesis that the conifers are allied to the Amentiferae, as has long been held by many botanists. It is no longer necessary to begin the phylogeny of angiosperms with apetalous forms so as to make easier the passage from Coniferae. In fact, for many years there have been those who held that apetalous plants are not primitive, but on the contrary have been derived from petalous forms by reduction. Sixty years ago or more Jussieu hinted at the real nature of apetalous plants[8] and suggested the primitive nature of the Ranales, and consistently placed the Compositae at the summit of his system.

In the vice-presidential address[9] which I had the honor of delivering before this section fifteen years ago, after a careful examination of the families in the so-called Apetalae the conclusion was reached that "when we search for families in the Apetalae which may satisfy the requirements of a primitive group from which the dicotyledons may have evolved, we find none which will serve our purpose." Following the hint of Jussieu, the attempt was made to distribute the apetalous families among polypetalous and gamopetalous orders. A revision of the monocotyledonous and dicotyledonous orders was made so as to bring the apocarpous families near the beginning (lowest) point. Thus the water-plantains (*Alismales*) were given the first (lowest) place among monocotyledons, and buttercups (*Ranales*) and roses (*Rosales*) similar places among dicotyledons. From the water plantains (*Alismales*) a phyletic line was traced through the lilies (*Liliales*) to the modified (simplified) calla lilies (*Aroidales*), palms (*Palmales*) and grasses (*Graminales*), which form lateral offshoots of the main line, and then onward from lilies (*Liliales*) through irises (*Iridales*) to orchids (*Orchidales*). In like manner a phyletic line was traced from buttercups (*Ranales*) to pinks (*Caryophyllales*), prim-

[7] "American Fossil Cycads," by G. R. Wieland, 1906.

[8] "The Elements of Botany," by Adrien de Jussieu; translated by Wilson, 1848, p. 543.

[9] *Proceedings* of the American Association for the Advancement of Science, Vol. XLII., 1893, p. 245.

roses (*Primulales*), phloxes (*Polemoniales*) to figworts (*Personales*) and mints (*Lamiales*). Another line was sketched from roses (*Rosales*) to umbelworts (*Umbellales*), madders (*Rubiales*) and sunflowers (*Asterales*). Certain details of that arrangement, as the disposition of *Celastrales* and *Sapindales*, and the retention of the *Choripetalae* and *Gamopetalae* as valid groups, were subsequently found to be erroneous, and were corrected, but in the main the system as then outlined has been sustained by subsequent careful studies of the families.

Two years later[10] this general arrangement was expanded so as to include brief characterizations of the orders, suborders and families, and in it the *Celastrales* and *Sapindales* were brought into the phyletic line extending from *Rosales* to *Asterales*, but the *Choripetalae* and *Gamopetalae* were still recognized as valid groups.

A year later, in an elementary textbook[11] the *Choripetalae* and *Gamopetalae* were abandoned as definite groups of angiospermous orders, since it is evident that gamopetaly has been attained independently in at least two phyletic lines.

In my presidential address[12] before the Botanical Society of America in 1897, the dicotyledons were arranged in "two somewhat diverging genetic lines or phyla, each beginning with apocarpous, hypogynous, choripetalous plants, and both attaining syncarpy and gamopetaly, one remaining hypogynous, the other becoming epigynous." A little later it is explained that "since gamopetaly has evidently been attained at more than one point, it is no longer desirable to retain the *Gamopetalae* as a distinct group."

The latest restatement of this arrangement of the flowering plants was published at the beginning of the present year in my "Synopsis of Plant Phyla,"[13] already referred to earlier in this address. In it many minor corrections were made, and some suggestions were hazarded as to the point of origin of angiosperms, and conifers. These suggestions followed the line sketched by Arber and Parkin in their paper on the "Origin of Angiosperms"[14] published a few months earlier. Basing their argument upon the discoveries of Wieland[15] these authors concluded that angiosperms were derived from Cycadean ancestors of the Bennettitean type, with an open flower-like strobilus ("pro-anthostrobilus") of megasporophylls, microsporophylls ("amphisporangiate") and asporophylls ("perianth"). As a consequence they arrive at the conclusion that primitive angiosperms were necessarily polypetalous, hypogynous and apocarpous, precisely the conclusion reached by me on theoretical grounds more than fifteen years ago, and since then persistently held in the face of the increasing popularity of Engler's system. It would now appear probable that there must soon be another rearrangement of the flowering plants. We have recently witnessed the almost complete inversion of the sequence of the families of flowering plants in our systematic manuals, and it appears now that we shall barely have time to become accustomed to the new order before we shall have to learn still another. It seems now inevitable that such orders as

[10] In Johnson's "Universal Cyclopedia," Vol. VIII. (1895).

[11] "The Essentials of Botany," sixth edition, 1896, p. 322.

[12] "The Phylogeny and Taxonomy of Angiosperms," August 17, 1897. Published in *Botanical Gazette*, Vol. XXIV., p. 145.

[13] "A Synopsis of Plant Phyla," in *University of Nebraska Studies*, October, 1907 (issued February, 1908).

[14] "The Origin of Angiosperms," by F. A. Newell Arber and John Parkin, in *Linnean Society's Journal—Botany*, Vol. XXXVIII., July, 1907.

[15] "American Fossil Cycads," 1906.

the buttercups (*Ranales*), water plantains (*Alismales*), and roses (*Rosales*) are to be regarded as primitive, and as a consequence they must stand at the beginning of the great phylum *Anthophyta*, as also each must stand at the beginning of its smaller phylum. That the phylum beginning with the water plantains (*Alismales*) must find its highest development in the irises (*Iridales*) and orchids (*Orchidales*) can not be doubted; nor can it be questioned that grasses (*Graminales*), calla lilies (*Aroidales*) and palms (*Palmales*) must now stand as reduced from the type of the lilies (*Liliales*). This leaves no room for radical differences of opinion, and in fact little room for any but the most minor differences in regard to the proper sequence of the monocotyledonous families.

In like manner beginning with the Ranalian type in the dicotyledons, it is obvious that one phyletic line culminates in the gamopetalous, bicarpellate, hypogynous order of the mints (*Lamiales*), while another passes through the roses (*Rosales*) (if indeed they are not themselves primitive), and umbelworts (*Umbellales*) to the sunflowers (*Asterales*). Here again, with regard to the details as to the intermediate orders there may be much difference of opinion. Yet there will be no question that in one line the pinks (*Caryophyllales*) and mallows (*Malvales*) are lower than primroses (*Primulales*) and heaths (*Ericales*), nor that the latter are lower than phloxes (*Polemoniales*) and mints (*Lamiales*). In the other line the myrtles (*Myrtales*) are clearly lower than umbelworts (*Umbellales*), while the latter are manifestly lower than madders (*Rubiales*), and these than sunflowers (*Asterales*). In fact when we agree to the hypothesis that polypetalous, hypogynous, apocarpous flowers are primitive the great outlines of the phylum (or phyla) are quite obvious, and the only questionable points are with reference to the place and sequence of intermediate orders. And it is here that much critical work invites the close attention of taxonomists. The great outlines—the boundaries of the phyla—are drawn, but the particular manner in which many of the interior families are related to each other has not yet been made out.

The principles here brought forward, and the general plan which I have so hastily sketched, have been so serviceable in the presentation of the subject of taxonomy in my lectures to university students that I venture to lay them before you as a general working hypothesis. My own success in its use encourages me in the hope that in the hands of others it may be equally helpful in enabling the student of taxonomy to more clearly apprehend the mode of evolution in the vegetable kingdom, and the consequent relationship of the resulting multiplicity of types.

Charles E. Bessey
The University of Nebraska

THE DARWIN CENTENARY AT CAMBRIDGE

Some details are given in the London *Times* of the celebration by the University of Cambridge of the centenary of the birth of Charles Darwin and the jubilee of the first publication of "The Origin of Species." It is expected that delegates selected by universities, academies, colleges and learned societies will arrive in Cambridge on Tuesday, June 22, and that the arrangements for their entertainment, which are, however, subject to alteration, will be as follows: On the evening of the twenty-second there will be a reception, probably in the Fitzwilliam Museum, by the chancellor. On Wednesday, June 23, addresses will be presented by the delegates to the university in the senate house. It is hoped to present to each delegate a copy of the first draft of "The Origin of Species." In the afternoon there will be a garden party at Christ's College, where Darwin was a stu-